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Guidelines for the Interpretation of Air Quality Standards

(U.S.) Environmental Protection Agency
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This guideline document discusses a series of issues concerning the interpretation of air quality data as it relates to the National Ambient Air Quality Standards (NAAQS). The issues presented deal with points of interpretation that have frequently resulted in requests for further clarification. This document states each issue with a recommendation and a discussion indicating our current position. It is hoped that this document will serve as a useful step in the evolutionary development of a uniform and consistent set of criteria for relating ambient air quality data to the NAAQS.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Air Quality Planning and Standards

Research Triangle Park, North Carolina

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GUIDELINES FOR THE INTERPRETATION OF AIR QUALITY STANDARDS

August 1974

U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Monitoring and Data Analysis Division
Research Triangle Park, North Carolina 27711

INTRODUCTION

This guideline document discusses a series of issues concerning the interpretation of air quality data as it relates to the National Ambient Air Quality Standards (NAAQS). The issues presented deal with points of interpretation that have frequently resulted in requests for further clarification. This document states each issue with a recommendation and a discussion indicating our current position. It is hoped that this document will serve as a useful step in the evolutionary development of a uniform and consistent set of criteria for relating ambient air quality data to the NAAQS.

ISSUE 1: Given that there are a number of monitoring sites within an Air Quality Control Region (AQCR), does each of these sites have to meet the National Ambient Air Quality Standards (NAAQS)? In particular, if only one of these sites exceeds a standard, does that mean that the AQCR is in nonconformance of the standards even though all other sites meet the standard?

Recommendation

Each monitoring site within the AQCR must meet the standard or the region is in nonconformance with that standard.

Discussion

The NAAQS' were defined to protect human health and welfare. The presence of one monitoring site within an AQCR violating any given standard indicates that receptors are being exposed to possibly harmful pollutant concentrations.

Concentrations in excess of standard values at a single monitoring station may result from the effect of a small, nearby source which is insignificant in terms of the total emission inventory, or the station in violation may be so located that the probability that individuals would be exposed for prolonged periods is negligible. Such circumstances do not mitigate the recommended interpretation of the question raised by this issue since NAAQS are generally interpreted as being set to protect health and welfare regardless of the population density. Although air quality improvement should be stressed in areas of maximum concentrations and areas of highest population exposure, the goal of ultimately achieving standards should apply to all locales. Data from monitoring sites are the only available measure of air quality and must be accepted at face value. Attention is thus focused on the selection of monitoring sites in terms of the representativeness of the air they sample. This is discussed in more detail in the guideline series document entitled "Guidance for Air Quality Monitoring Network Design and Instrument Siting," (OAQPS No. 1.2-012). Consideration should be given to the relocation of monitoring stations not meeting the guideline criteria.

ISSUE 2: How many significant figures should be employed when making comparisons with the NAAQS and what system of units should be used?

Recommendation

Comparisons with the standards should be made after converting the raw data to micrograms (or milligrams) per cubic meter. All comparisons are made after rounding the air quality value to the nearest integer value in micrograms per cubic meter (or milligrams per cubic meter for carbon monoxide). The rounding convention to be employed is that values whose fractional part is greater than or equal to .50 should be rounded up and those less than 0.50 should be rounded down. The following examples should clarify these points.

Computed Value	Rounded Value
79.50	80
80.12	80
80.51	81
81.50	82

Discussion

By letting the standard itself dictate the number of significant figures to be used in comparisons, many computational details are minimized while still maintaining a level of protection that is consistent with the standard. It should be noted that the parenthetical expressions given in the NAAQS indicating parts per million (ppm) may be used as a guide but in some cases, such as the annual standard for sulfur dioxide, may require additional signficant figures to be equivalent.

ISSUE 3: Short-term standards are specified as concentrations which are not to be exceeded more than once per year. How is this to be interpreted when analyzing data obtained from multiple monitoring sites?

Recommendation

Each site is allowed one excursion above the standard per year. If any site exceeds the standard more than once per year, a violation has occurred.

Discussion

By examining each site separately, data processing problems are lessened and, more importantly, regions employing more than the required minimum number of monitoring sites would not be unduly penalized.

ISSUE 4: How should compliance with the NAAQS by July 1975 and 1977 be determined?

Recommendation

Base the preliminary determination of compliance on adherence to the implementation plan emission reduction schedules. Confirm compliance with NAAQS by air quality surveillance during the calendar year 1976. However, noncompliance with short-term standards can be determined during the last six months of 1975 if two concentrations in excess of the standards occur. Similarly, for AQCRs or states which do not have to achieve NAAQS until 1977, compliance would be based on data obtained in 1978.

Discussion

Implementation plans based on bringing many individual or categories of sources into compliance with emission regulations by July 1975 have been granted at least conditional approval. However, a twelve-month period of air quality surveillance is required to determine annual average air quality values. Further, the calendar year has been recommended as the time unit for the calculation of annual average concentrations (see Issue 5). Obviously the calendar year of data required to demonstrate that annual NAAQS have been achieved by the control activities fully implemented by July 1975 cannot begin before 1 January 1976. Noncompliance with short period standards can be determined in less than a calendar year by the occurrence of two concentrations in excess of the NAAQS. Before an AQCR can be said to be in compliance with short-term NAAQS, a full twelve-month period of air quality surveillance records, encompassing all four seasons, must be available for examination.

ISSUE 5: What period of record of air quality data is necessary to establish the status of an AQCR with respect to the NAAQS?

Recommendation

Each AQCR should be treated as a separate case in establishing its status with respect to the NAAQS (this issue should be considered in conjunction with Issue 4).

Discussion

Although each AQCR would be examined individually, the gradual establishment of precedents would eventually provide consistency. This option would consider differences in monitoring coverage, meteorology, the type and mix of sources, and unusual economic circumstances. Case by case treatment would allow greater flexibility in examining borderline cases, such as annual averages which fluctuate around the standard, or short-term excursions above the air quality standards. Use of this option is illustrated by the following examples: (1) SO_2 concentrations during the heating season in a northern AQCR are lower than the short-term standards. If it can be shown that the number of hearing degree days, the industrial activity, and the dilution capacity of the atmosphere favored the occurrence of high SO_2 concentrations, then the status of the AQCR with respect to the NAAQS would be evaluated accordingly, (2) eight-hour average CO concentrations in an AQCR fluctuate about the standard. The period of record was unusually favorable for the dispersion of pollutants. Hence, a longer and more representative period of record is required to evaluate the status of this AQCR with respect to the NAAQS.

ISSUE 6: The NAAQS are defined in terms of a year, i.e., annual mean concentrations and short-term concentrations not to be exceeded more than once per year. What is meant by the term "year" and how frequently should air quality summaries be prepared to conform to that definition?

Recommendation

The term "year" means a calendar year and air quality summaries should be prepared for that period.

Discussion

While pollutant exposures may overlap calendar years, the use of a calendar year for air quality summaries remains a simple and conventional practice. Indeed, inquiries concerning air quality are most frequently expressed in terms of a calendar year. The data do not warrant quarterly evaluation of compliance or noncompliance with NAAQS, nor would it be reasonable to revise emission control requirements on a quarterly basis. This of course does not remove the need for continual appraisal of air quality on a quarterly or monthly basis to assess both status and progress with respect to the standards. Such efforts are obviously useful and sometimes necessary to ensure that standards are met on a calendar year basis.

ISSUE 7A: The NAAQS for CO and SO_2 include eight-hour and three-hour averages, respectively. For such standards how is the time interval defined?

Recommendation

Compliance with these standards should be judged on the basis of running averages starting at each clock-hour. However, in determining violations of the standard the problem of overlap must be considered. This point can best be illustrated by consideration of the 8-hour CO average. In order to exceed the 8-hour CO standard twice there must be two 8-hour averages above the standard and the time periods for these averages must not contain any common hourly data points. A simple counting procedure for this interpretation for 8-hour CO is to proceed sequentially through the data and each time a violation is recorded the next seven clock hours are ignored and then the counting is resumed. In this way there is no problem with overlap.

Discussion

This issue has generated considerable interest concerning the relative merits of fixed versus running averages. At the present time the computational advantages of the fixed interval approach are outweighed by the following properties of running averages: (1) running averages afford more protection than fixed averages and this additional margin appears warranted, (2) running averages more accurately reflect the dosage to receptors and (3) running averages provide more equitable control from one region to another due to differences in diurnal patterns.

In discussing this issue there are certain related points that are worth mentioning. It should be noted that a clock-hour is the smallest time interval suggested for reporting data and that 24-hour averages are interpreted as daily averages. Factors influencing these suggestions include computational complexity, differences in reporting intervals for various measurement methods, and the need to maintain both uniform and consistent control from one region to another.

While the proposed counting scheme determines the number of times the standard is exceeded the second highest value is commonly used for planning purposes. The determination of the second highest value in the case of running averages has certain technical subtleties that are discussed in detail in issue 7B.

ISSUE 7B: When using running averages for 8-hour and 3-hour averages how should the second highest value be determined?

Recommendation

The second highest value should be determined so that there is one other non-overlapping value that is at least as high as the second highest value. Although this seems relatively straightforward the following discussion indicates some of the subtleties involved.

Discussion

The use of running averages to determine compliance with specific air quality standards necessitates that the number of values above the standard be evaluated on the basis of non-overlapping time periods. That is, any two values above the standard must be distinct and not have any common hours. This can be achieved by a relatively straightforward counting procedure. For example, in the case of 8-hour CO an 8-hour average can be associated with each clock hour of the calendar year. Then values above the 8-hour standard are counted sequentially beginning with the first 8-hour average of the year. Each time a violation is counted the next seven 8-hour values are ignored, and the counting procedure resumes with the eighth 8-hour average. This counting procedure results in the maximum number of non-overlapping violations of the 8-hour standard.

This count is all that is needed to evaluate compliance with the 8-hour standard because the standard is not to be exceeded more than once per year; and, therefore, any count value greater than one is sufficient to indicate non-compliance. However, it is also desirable to employ the second highest 8-hour average to indicate the magnitude of the problem. There are several ways to define the second highest value, and three possible definitions will be indicated here in order to briefly discuss their consistency with the counting procedure described above. The three definitions considered for the second highest value are: 1) the second highest 8-hour value of those counted as being above the standard, 2) the second highest 8-hour value that does not overlap the maximum 8-hour value, and 3) the maximum second highest non-overlapping 8-hour average.

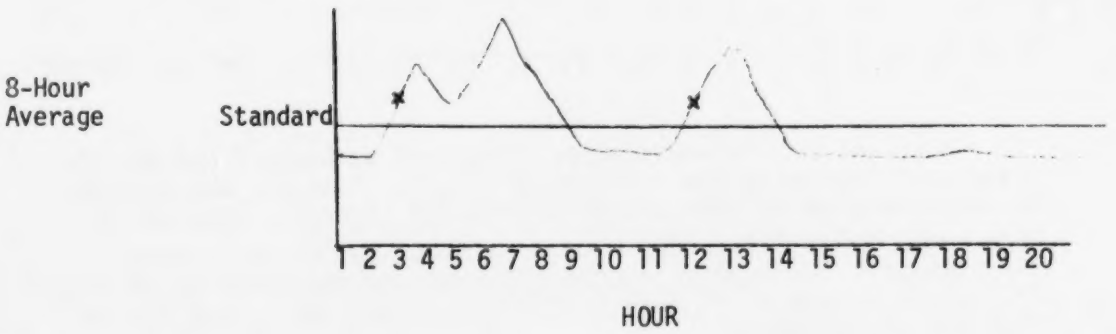
Annotated graphs of 8-hour CO are used to facilitate the discussion of the consequences of each definition. For example, Figure 1 illustrates that the first definition underestimates the magnitude of the problem because the counting procedure may count the first time the standard is exceeded and bypass the peak values. Therefore this definition is inadequate.

Although the second definition is intuitively appealing, Figure 2 illustrates that in some cases there could be two violations of the standard, and yet the second highest value that does not overlap the maximum is less than the standard. This can only occur in marginal cases in which the standard is only exceeded during one fifteen hour period in the year and that the maximum value occurs in the middle of this interval. Figure 3a and 3b show another case in which this definition produces the peculiarity that a higher CO value may lower the second highest value.

In order to avoid these inconsistencies it becomes necessary to define the second highest value as the maximum second highest non-overlapping value. What this means is that there is one 8-hour value that is greater than or equal to the maximum second highest value and that these two values are not overlapping. It is important to recognize that the maximum second highest value may overlap the maximum 8-hour value. However, as shown in Figure 2, there is still one other 8-hour non-overlapping value that exceeds the maximum second high.

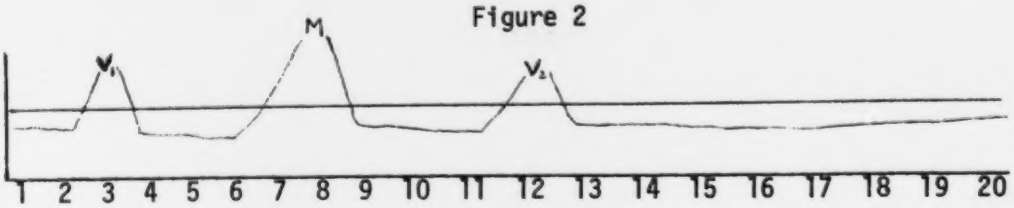
With these subtleties in mind, it seems appropriate to use the maximum second highest non-overlapping value as the second high. In this way, the magnitude of the problem is properly assessed; and the second high value is always consistent with the number of violations. This definition of the second highest value is also consistent with the approach used in determining control strategies on the basis of the roll-back equation. It is this maximum second highest value that must be reduced below the standard in order to satisfy the requirement that the standard not be exceeded more than once per year.

Figure 1



Using the counting procedure the violations are counted at hours 3 and 12 as indicated by the x's. Note that the peak values do not occur at these points.

Figure 2



There are two non-overlapping violations at hours 3 and 12, and these are detected by the counting procedure. However, the maximum occurs at hour 8 and the second is below the standard. However in this case the maximum second maximum would be V_2, which is above the standard. Although V_2 overlaps the maximum, M, there is one eight-hour average, namely V_1, that is at least as high as V_2 and the two time periods are disjoint.

Figure 3a

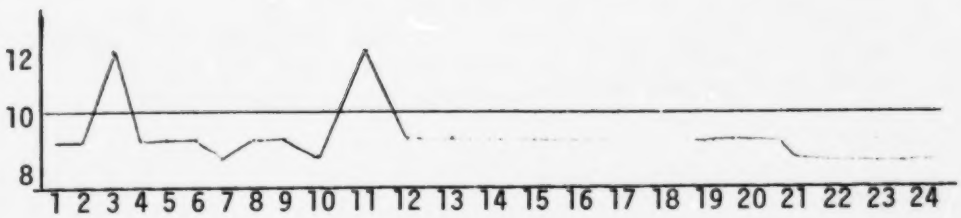
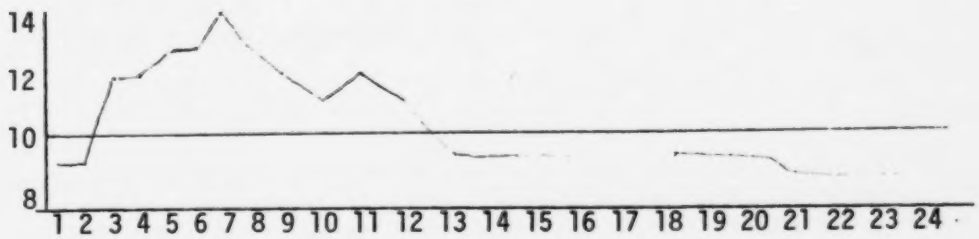


Figure 3b



In Figure 3a the maximum value is 12 as well as the second highest value. However, in Figure 3b the maximum is now 14, and the second highest value that does not overlap the 14 is below the standard. Therefore the second highest value that does not overlap the maximum can actually be lowered by having more high values. It should be noted that in both of the above cases the maximum second highest non-overlapping value is 12.

Issue 8: The chances of detecting violations of 24-hour maximum standards depend considerably upon the frequency with which the air is monitored. In view of this, how should data obtained from intermittent monitoring be interpreted?

Recommendation

Sampling at monitoring sites which yields only partial annual coverage is not necessarily sufficient to show compliance with "once per year" standards. Although noncompliance will not be declared on the basis of predicted values, it is possible that predicted values in excess of the standard may necessitate more frequent sampling at a particular site.

Discussion

Ideally, continuous monitoring of all pollutants would be conducted. However, except for those pollutants specified in Federal regulations, EPA does not currently require continuous monitoring. Thus, one is left with either (1) predictive equations employing data from partial annual coverage, or (2) the data collected through partial annual coverage. Since the accuracy of predictive equations is not well established, the remaining alternative is to judge compliance on the basis of partial annual coverage; however, states at their option, could sample more frequently than the required minimum. Partial annual coverage schedules make detection of short-term violations difficult. The entries in the following table are the probabilities of choosing two or more days on which excursions have occurred for different numbers of actual excursions above the standard and different sampling frequencies. The underlying assumption in determining these probabilities is that excursions above the standard occur randomly over the days of the year. This is, of course, an oversimplification but is sufficient for the purposes of this discussion.

Probability of selecting two or more days when site is above standard

Actual Number of excursions	Sampling Frequency - days per year 61/365	122/365	183/365
2	0.03	0.11	0.25
4	0.13	0.41	0.69
6	0.26	0.65	0.89
8	0.40	0.81	0.96
10	0.52	0.90	0.99
12	0.62	0.95	0.99
14	0.71	0.97	0.99
16	0.78	0.98	0.99
18	0.83	0.99	0.99
20	0.87	0.99	0.99
22	0.91	0.99	0.99
24	0.93	0.99	0.99
26	0.95	0.99	0.99

From this table it is clear that the frequency of sampling must be considered in judging compliance with "once per year" standards. The present recommendation was selected so that more frequent monitoring does not inherently penalize a given area. At the same time a certain degree of flexibility in the use of predictive equations such as the one discussed by Larsen ("A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards," EPA Publication No. AP-89) is left to those who evaluate compliance. At the present time it is difficult to suggest a predictive equation that has equal validity at all sites. It is felt that this determination should be made on a case by case basis after a detailed evaluation of the site in question.

ISSUE 9: How should particulate matter, CO and other pollutant concentrations resulting from severe recurring dust storms, forest fires, volcanic activity and other natural sources be taken into account in determining compliance with NAAQS?

Recommendation

Regardless of the source, ambient pollutant concentrations exceeding a NAAQS constitute a violation.

Discussion

Ambient pollutant concentrations exceeding the NAAQS and resulting from emissions from natural sources constitute a violation. However, such violations should not be used as a basis for developing or revising an existing, across-the-board control strategy.

ISSUE 10: Should all available air quality data or only those derived from air quality surveillance systems, as specified in a state implementation plan (SIP), be used to determine compliance with NAAQS?

Recommendation

All available valid air quality data representative of the exposure of receptors can be used to determine compliance with NAAQS. This includes data obtained from the air quality surveillance system specified in the applicable SIP, data obtained from the National Air Surveillance Network (NASN), data obtained by industry monitoring stations, data obtained from monitoring stations installed and operated by concerned citizens, etc.

Discussion

NAAQS have been established to protect the health and welfare of the population. If the NAAQS have validity, the violation of a standard at any point in the AQCR is significant. Even though a station is not part of the established surveillance network, if acceptable methods, procedures, calibrations and recordings have been used and can be verified, and the station is located in accordance with applicable criteria for representativeness, the data from that station should be used for the determination of conformity with NAAQS.

ISSUE 11: May monitoring for certain pollutants be restricted to only a portion of the day? For example, in the case of oxidant, which has a clear diurnal pattern, would it suffice to monitor only during the hours from 8 a.m. to 6 p.m.?

Recommendation

Partial daily monitoring of pollutants subject to short-term NAAQS is not allowed (except nonmethane hydrocarbons where 6-9 a.m. is specified in the NAAQS). All hours of the day must be monitored, except perhaps for one hour missed during instrument calibration, and reported, and will be used in evaluating compliance.

Discussion

While specific pollutants show rather consistent diurnal patterns of concentration, particularly when mean hourly values are considered, the concentration patterns are subject to modification with both seasonal and short period changes of meteorological conditions. This is most noticeable when a region is subjected to episode conditions. In addition, the actual local time of occurrence of periods of high concentrations will vary from AQCR to AQCR and perhaps from monitoring station to monitoring station within an AQCR. Extensive study of patterns and trends exhibited by pollutant concentrations within each AQCR would be required to select the portion of the day to be monitored if partial monitoring were allowed. Further, monitoring data for the full twenty-four hour period will help determine the extent and duration of episodes and contribute to the determination of the need for emergency control measures.

It should be noted that automatic monitoring devices used to obtain sequential hourly data are seldom amenable to shut-down and subsequent start-up without a warm-up and stabilization period.